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Spatial variation in fish communities in two South-western Australian river systems

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Abstract

The fish fauna of two river systems, the Canning and North Dandalup catchments, were sampled every 3 months over an 18 month period. Similar numbers of species and individuals were recorded from both systems. The majority of headwater streams were temporary, predominantly colonized by the native minnow, *Galaxias occidentalis*. Physical obstruction to the seasonal migration of this species by both natural and man-made barriers was evident.

At lowland sites an exotic, *Gambusia affinis*, was dominant in the Canning River, and was the second most abundant species in the North Dandalup River. The distribution of *G. affinis* is discussed in relation to streamflow regulation, disturbance and habitat requirements.

Introduction

The freshwater piscifauna of South-western Australia is considered a distinct element of the Australian fish fauna and has been described as depauperate, with a high degree of endemism (Whitley 1947, Allen 1982, Merrick & Schmida 1984). The fauna is represented by eight families (one monotypic and endemic) containing 12 genera and 17 species. Nine species and six genera, four of which are monotypic, are endemic to the State. Within the state, regional patterns of endemism are also apparent for some species (Christensen 1982). A number of exotic species are present, most notably the mosquito fish, *Gambusia affinis* (Bird & Girard).

Despite the low number of species, little is known of their biology, apart from the above gross patterns of distribution. In addition, little is known of the impact of introduced species. *G. affinis* is widespread throughout the South-west of Australia (Allen 1982) and much of the Australian continent (Merrick & Schmida 1984). This species has been implicated in the elimination of native species from many systems (Myers 1975, Mees 1977, Sarti & Allen 1978, Arthington *et al* 1983), yet little is known of the interactions between this and native species in South-western Australia.

This paper describes patterns in the distribution of the fish fauna of two river systems, the Canning and the North Dandalup and formed part of an extensive biological monitoring programme for environmental impact assessment and water quality using fish and macroinvertebrates.

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Study areas

The location of sampling sites within each river system is illustrated in Figure 1. The headwaters of both rivers are situated in forested regions *(Eucalyptus marginata* and *E. calophylla)* of the Darling Scarp, the western edge of the Great Plateau of Western Australia (Jutson 1950). In the Canning catchment these streams are intermittent while in the North Dandalup they are more permanent. This is related to the higher annual rainfall and the presence of swamps on the headwaters of the latter system. The climate of the area is mediterranean (Seddon 1972) with predictable patterns of rainfall and stream discharge (Bunn *et al* 1986).

Both river systems are regulated, resulting in reduced summer flow at the majority of lowland sites. On the Canning River a large dam (built *c* 1932) is situated 2km upstream of site LC1. Below this dam a number of short tributaries, one of which is Stinton Creek, arise from adjoining sub-catchments. On the North Dandalup River a pipehead dam, which overflows each winter, is situated upstream of site ND5. In contrast this river receives little additional input from sub-catchments. Many of the streams of both catchments are impounded by V-notch weirs for gauging discharge. A riparian release valve, periodically opened to augment low summer flow, is situated immediately upstream of site LC6.

The headwater streams of both rivers are enclosed in a thick canopy of riparian vegetation, which is also a feature of some of the Lower Canning River sites (LC1-4). The lower reaches of the Canning system flow through urban areas, while downstream sites on the North Dandalup are situated in rural areas where riparian vegetation has been reduced by stock grazing.

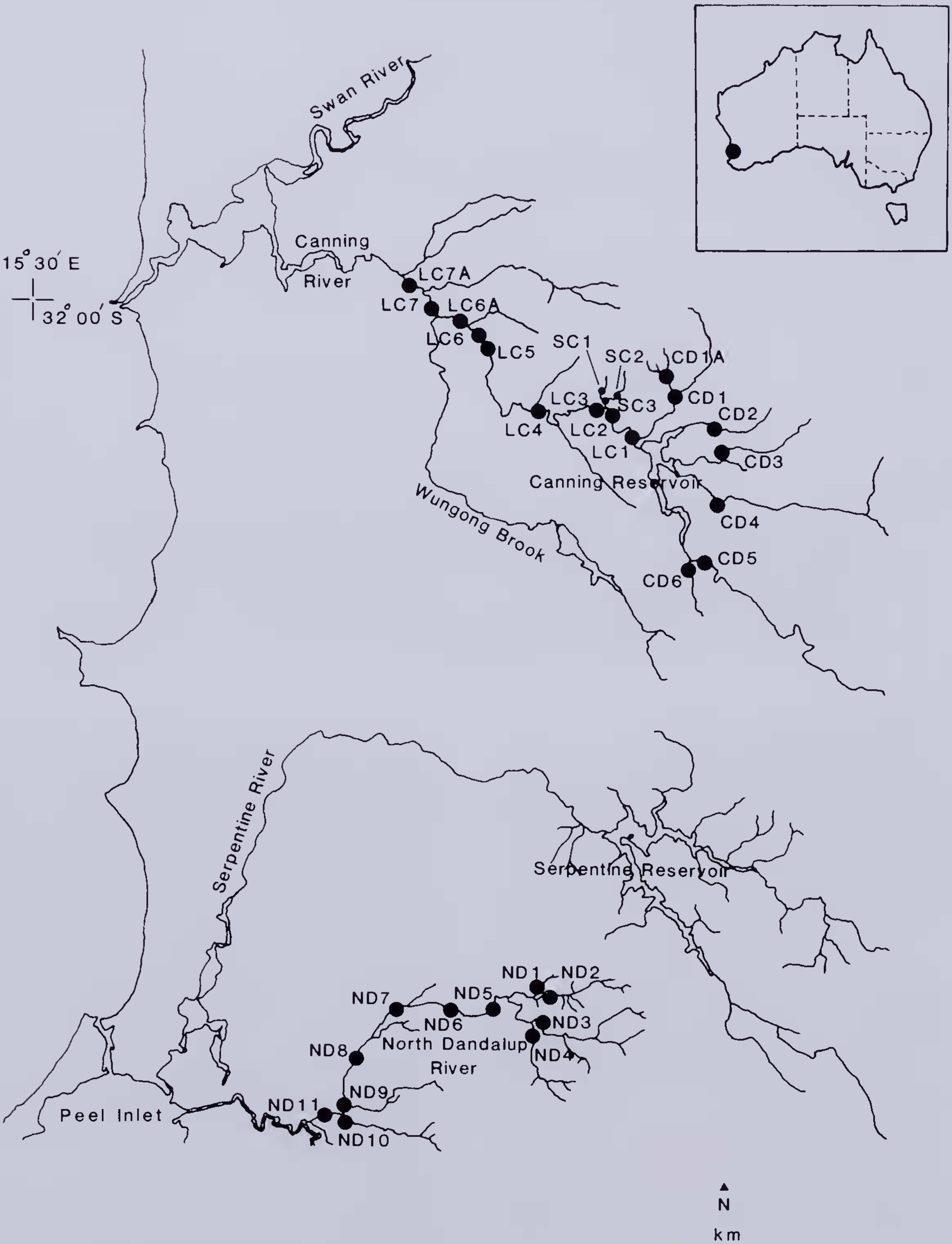

Figure 1 The location of study sites in the Canning and North Dandalup Rivers.

Methods

Sampling regime

Quarterly sampling was implemented from March 1985 to September 1986. A total of 30 sites was routinely sampled, with 11 sites in the North Dandalup and 19 in the Canning catchment. Sites were initially selected by the presence of riffle zones for macroinvertebrate sampling; however fish samples included both riffle and pool habitats.

At each site fish communities were sampled by seine and hand netting. The 5m wide purse type seine net, with a 9mm stretched mesh size, was placed across the stream and fish were driven downstream into the net over a 50-100m reach. Submerged vegetation, logs and large rocks were swept with standard FBA handnets (1.00mm mesh size). Sampling time was standardized to 2 person-hours at each site.

All fish taken were identified, enumerated and released. Species richness (S), taken as total number of species in each sample, was determined for each site on each sampling occasion.

Data analyses

One-way ANOVAs were used to test the significance of between-site changes in the above parameters. Prior to analyses, Cochran's C and Bartlett's Box tests were used to measure homogeneity of variances (Zar 1974). Square root or logarithmic transformations were used if variances were heteroscedastic.

Results

Composition of the fish fauna

Canning Catchment Eight species of fish were sampled (Figure 2). The most commonly taken fish was the exotic, *Gambusia affinis,* comprising 48.3% of the total. The pygmy perch, *Edelia vittata* Castelnau was the next most abundant species (23.5%), followed by the western minnow, *Galaxias occidentalis* Ogilby (16.9%). Two other species; silverside, *Atherinosoma wallacei* Prince, Ivantsoff & Potter and goby, *Pseudogobius olorum* (Sauvage) contributed 7.2 and 2.9% of the total respectively. The remainder (1.2%) was composed of the nightfish, *Bostockia porosa* Castelnau, the cobbler, *Tandanus bostocki* Whitley and the goby *Favonigobius suppositus* (Sauvage). A total of 2 593 fish was caught in the Canning River, 80.2% of which were collected from lower river sites, with the remainder spread evenly between the headwater streams. No fish were collected at the headwater sites SC1, SC2, CD1A & CD4.

North Dandalup Catchment Eight species of fish, totalling 2 182 individuals were sampled from the North Dandalup Catchment (Figure 3). This catchment contained one additional species, the exotic rainbow trout *Salmo gairdneri* Richardson. The goby, *F. suppositus*, present in the Canning Catchment, was not taken. The most common fish, comprising 71.5% of the total number caught, was *G. occidentalis*. *G. affinis* comprised 19.2% of the total and was the second most abundant species. *E. vittata* and *A. wallacei* made up 6.7% and 1.6% of the total respectively. The remaining four species; *B. porosa, T. bostocki, P. olorum* and *S. gairdneri,* comprised 1% of the total abundance.

Spatial variation in community structure

Canning Catchment Between-site differences in species richness (Figure 2) were significant (ANOVA $F=2.2062$, $P < 0.05$, df 8,45). Sites LC1, LC5 & LC6 had a lower species richness than all other lowland sites (Duncan's Multiple Range test (DMR), $P < 0.05$).

G. affinis, the dominant species in the lower Canning system, demonstrated a significant between-site difference in relative abundance (ANOVA $F=6.3905$, $P < 0.001$, df 8,45), with sites LC6 & LC7A significantly higher than all other lowland sites, with the exception of site LC2 (DMR, $P < 0.05$).

E. vittata, widely distributed throughout the lower Canning system (Figure 2), demonstrated significant between-site differences in relative abundance (ANOVA, $F=6.369$, $P < 0.001$, df 8,45). This species had a significantly higher relative abundance at sites LC1, LC3, LC4 and LC6A than all other lower sites (DMR, $P < 0.05$). *E. vittata* was not taken from site LC6.

G. occidentalis, the third most abundant species in the Canning system, was widely distributed throughout the catchment, with a higher relative abundance in the headwater sites.

The remaining five species were mainly restricted to lower sites, with low relative abundances. *A. wallacei* was an exception, comprising approximately 40% of the total catch taken from site LC4.

North Dandalup River Between-site differences in species richness were significant (Figure 3) (ANOVA, $F=6.5184$, $P < 0.05$, df 10,66). Sites ND4, ND6, ND8, ND9, ND10 & ND11 had a higher species richness than sites ND1, ND2, ND3, ND5 & ND7 (DMR, $P < 0.05$).

G. occidentalis, the most abundant species, was widespread throughout the North Dandalup catchment (Figure 3) and dominated the headwater sites.

G. affinis and *E. vittata,* the second and third most dominant species respectively, were common but restricted to the lowland sites, downstream of the dam. *P. olorum, A. wallacei* and *T. bostocki* were also restricted to the lowland sites but were neither widespread nor abundant (Figure 3).

The remaining two species, *B. porosa* and *S. gairdneri,* were uncommon and taken only from headwater sites.

Discussion

The majority of the native species of fish recorded in freshwater rivers within 160km of Perth (Allen 1982) were collected during this study. Those not collected are either migratory or estuarine species that occasionally penetrate freshwater. Of the native species collected, only one, *Favonigobius suppositus,* was not recorded from both rivers, being absent from the North Dandalup and rare in the Canning system.

The distribution of species in the Canning and North Dandalup rivers fits that predicted by Horwitz (1978) for temporally variable rivers. Both systems demonstrated a low overall species richness, increasing slowly downstream and within the common species there was no downstream replacement, only additions. The greatest within-system differences in species richness occurred between headwater streams and the lower reaches of both rivers. This may be a reflexion of the effects of physical barriers to fish movement.

Several sites exhibited a community composition different from that expected. Species richness at site LC6 was markedly reduced from site LC5, 100 m upstream. This site is downstream of a riparian release valve from which treated water (chlorinated to 1ppm) is periodically released to augment reduced summer flow. It is unlikely that the change in community structure was solely due to elevated chlorine levels. Increased siltation and a disrupted food chain (macroinvertebrate community structure) may also be important factors. The effects do not appear to be long-lived

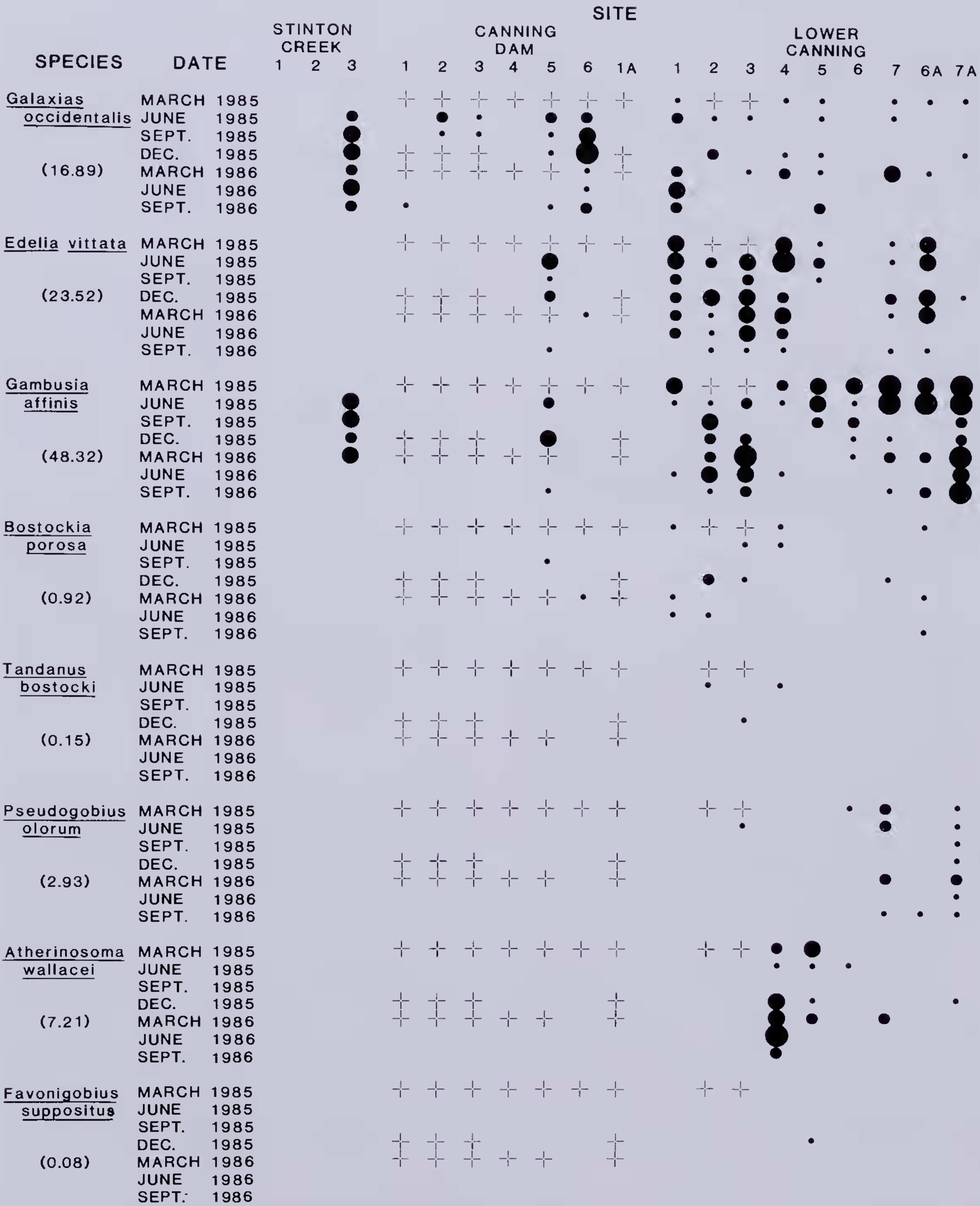

Figure 2 Spatial variation in the distribution of fish species in the Canning Catchment, March 1985 to September 1986 (Symbols indicate sample size: •, 1-5; ●, 6-20; ●, 21-50; ●, > 50; +, site dry); Values in parentheses represent percentage of total abundance of each species over the sampling period.

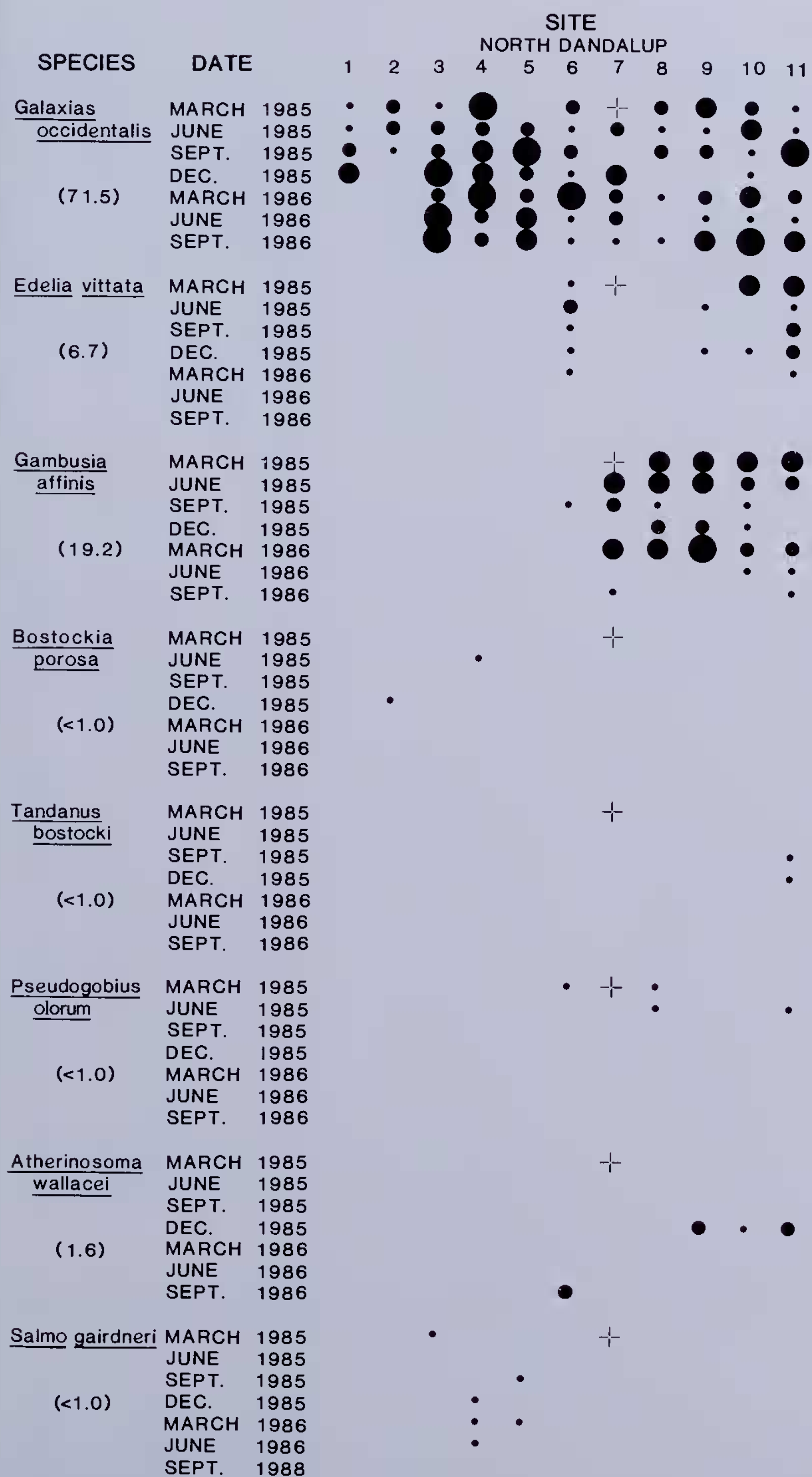

Figure 3 Spatial variation in the distribution of fish species in the North Dandalup Catchment, March 1985 to September 1986 (Symbols indicate sample size: •, 1-5; ●, 6-20; ●, 21-50; ●, > 50; +, site dry); Values in parentheses represent percentage of total abundance of each species over the sampling period.

with the river recovering by site LC6A, the next site downstream. Site LC7A, the most downstream Canning River site, also demonstrated a reduced species richness and diversity. This part of the river is both wide and deep reducing the effectiveness of the sampling method. More intensive sampling in the deeper sections of the river at this site may detect additional species.

Conversely, species richness at site CD5 of the Canning Dam catchment was higher than expected, with this site comparable to lower river sites. This stream, unlike the other catchment streams, did not dry up totally, but remained as large isolated pools throughout the summer. These pools may act as refugia and hold residual populations of *E. vittata*, *B. porosa* and *G. affinis* which may then rapidly recolonize site CD5 and to a lesser extent site CD6. These three species were not collected from any other catchment streams. This may be a reflexion of their inability to colonize newly inundated streams demonstrating, like many small temperate streams, that these are not highly favourable environments for fish colonization (Moyle & Vondracek 1985).

E. vittata and *B. porosa* are known to colonize rapidly floodplains of the south-west of Western Australia (Pusey unpubl). Spawning of these and a number of other sympatric species on the floodplains occurs in spring with the young feeding predominantly on planktonic crustacea. Temporary catchment streams, because of the paucity of planktonic fauna, may represent areas unfavourable for the development of young and this may restrict the distribution of these species. Horwitz (1978) reported planktivores to be uncommon in the headwaters of mid-western American rivers, presumably due to the unavailability of a suitable food source.

The temporary headwater streams of both river systems were recolonized rapidly by *G. occidentalis* soon after flow resumed. Little is known of the life history of this species in the streams of Western Australia, but it is thought that *G. occidentalis* performs an upstream migration to spawn in tributaries and headwater streams (EPA 1987). During this study large aggregations of *G. occidentalis* were frequently sampled at the base of V-notch weirs and on one occasion fish were observed, fully emersed, mid-way up the concrete spill-way below a weir face. This supports the view of an intended upstream movement. Spawning in headwater streams is also supported by the collection of gravid females at these sites. The same process may be occurring in the lower river because larvae and fry have been regularly sampled from drainage channels and flooded areas of the Swan Coastal Plain in winter (Edward unpubl). Migration up drainage channels and lowland tributaries may be an adaptation of populations of *G. occidentalis* which are isolated downstream of physical barriers *eg* waterfalls, dams and V-notch weirs. The action of such structures as barriers to fish movement would explain the absence of fish from two of the headwater streams, sites CD1A & CD4, which were both upstream of V-notch weirs. Fish were also absent from sites SC1 & SC2 which were upstream of a steep waterfall. This natural feature may be acting as a physical barrier to fish movement since aggregations of *G. occidentalis* were present at the base of the waterfall, at site SC3.

The construction of dams and V-notches is likely to have had a significant impact on the seasonal movements of *G. occidentalis,* affecting its reproductive biology and the recruitment of juveniles. Temporary headwater streams may be recolonized by residual populations of *G. occidentalis* within the reservoirs. Adult fish may actively retreat to the reservoir as stream flow decreases and it is also likely that if larvae are pelagic they will be swept downstream into the reservoir.

Both river systems were shown to have the same species richness. In the North Dandalup catchment the native species *G. occidentalis* was dominant while in the Canning system the introduced species *G. affinis* was most frequently encountered.

G. affinis was first introduced to the fresh waters around Perth in 1936 (Mees 1977) to control mosquitoes. The species now dominates many streams and lakes in the Perth area and is widespread throughout South-western Australia. Sarti & Allen (1978), in a survey of the wetlands of the northern Swan Coastal Plain, found that *G. affinis* was the most abundant species present in lentic habitats. Where native species were present in such habitats they were in low densities and usually confined to inlet streams. Native species were abundant in lotic habitats only (Moore River; ten native and one exotic species, Ellen Brook; seven native and one exotic species).

It is not known when *G. affinis* was first introduced to the North Dandalup River but as it is capable of rapid increases in population size it is unlikely that the difference in abundance between rivers is due to differing periods of residency.

It is inferred from this study that between-system differences in the stream environment influence the population size of *G. affinis*. The Canning system is regulated by a substantial dam which rarely overflows. As a result, the lower reaches of this river are wide, deep and relatively slow flowing, especially so in summer. This habitat is comparable to the lentic environment to which *G. affinis* seems particularly suited. On the North Dandalup system the pipehead dam above site ND5 overflows each winter making this river more prone to spates. Also, the lower reaches of the North Dandalup system are shallower and faster flowing possibly reducing suitability for colonization by *G. affinis*.

The role of disturbance in structuring fish communities may be important. Meffe (1984) found that *G. affinis* populations introduced to a Sonoran Desert stream incurred great losses during flashfloods. The Sonoran topminnow, *Poeciliopsis occidentalis*, endemic to the region, did not suffer such losses as a result of behavioural responses. Meffe *(op cit)* argues that fish which evolve in habitats with frequent perturbations exhibit behavioural responses that minimize the impact of disturbance. It seems likely that this is also the case in the Canning and North Dandalup systems. The high level of endemicity of the south-western fish fauna suggests that the evolution of the fauna has occurred *in situ* allowing sufficient time for the adaptation of behavioural responses to the seasonal regimes of stream discharge.

Meffe (1984) suggests that abiotic disturbance culminating in the almost complete removal of *G. affinis* allows the coexistence of this species and *P. occidentalis* in tributaries of the Santa Cruz River. A number of studies listed show replacement of *P. occidentalis* by *G. affinis* and all occurred in lentic environments.

Such a response, similar to the storage effect (Warner & Chesson 1985) in which coexistence is mediated by fluctuations in recruitment, may be involved in the coexistence of native species and *G. affinis* in streams and rivers of South-western Australia.

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References

Allen G R 1982 A field guide to inland fishes of Western Australia. Western Australian Museum, Perth.

Arthington A H, Milton D A & McKay R J 1983 Effects of urban development and habitat alterations on the distribution and abundance of native and exotic freshwater fish in the Brisbane region, Queensland. Aust J Ecol 8:87-101.

Bunn S E, Edward D H & Loneragan N R 1986 Spatial and temporal variation in the macroinvertebrate fauna of streams of the northern jarrah forest, Western Australia. Freshwater Biol 16:67-92.

Christensen P 1982 The distribution of *Lepidogalaxias salamandroides* and other small freshwater fishes in the lower south-west of Western Australia. J R Soc W Aust 65: 131-141.

EPA 1987 The effects of gauging station control structures on the native fish migration in freshwater streams of south west Australia. Environmental Protection Authority, Perth, Western Australia. Bull 282.

Horwitz R J 1978 Temporal variability patterns and the distribution patterns of stream fishes. Ecol Monogr 48:1173-1185.

Jutson J L 1950 The physiography of Western Australia, 3rd edn. Bull Geol Survey W Aust 95.

Mees G F 1977 The status of *Gambusia affinis* (Baird & Girard) in south-western Australia. Rec West Aust Mus 6:27-31.

Meffe G K 1984 Effects of abiotic disturbance on co-existence of predator-prey species. Ecology 65:1525-1534.

Merrick J R & Schmida G E 1984 Australian freshwater fishes: biology and management. J R Merrick, School of Biological Sciences, Macquarie University NSW.

Moyle P B & Vondracek B 1985 Persistence and structure of the fish assemblage in a small California stream. Ecology 66:1-13.

Myers G S 1975 *Gambusia*, the fish destroyer. Aust Zool 13:102.

Sarti N L & Allen G R 1978 The freshwater fishes of the Northern Swan Coastal Plain. In: Faunal studies of the Northern Swan Coastal Plain: A consideration of past and future changes. Report published by Western Australian Museum for the Department of Conservation and Environment pp 204-220.

Seddon G 1972 Sense of place. Univ W Aust Press, Nedlands.

Warner R R & Chesson P L 1985 Coexistence mediated by recruitment fluctuations: a field guide to the storage effect. Am Nat 125: 769-787.

Whitley G P 1947 The fluvifaunalae of Australia with particular reference to freshwater fishes in Western Australia. West Aust Nat 1:49-53.

Zar J H 1974 Biostatistical analysis. Prentice Hall, New Jersey.